U.S. Department
of Transportation

**Federal Aviation
Administration**

Advisory Circular

Subject: AIRCRAFT FIRE EXTINGUISHING AGENTS

Date: Draft

Initiated by: AAS-100

AC No: 150/5210-XX

Change:

1. **PURPOSE.** This advisory circular (AC) outlines the recommended levels of protection. This AC also provides (i) conversion factors for estimating the equivalency between various fire extinguishing agents; (ii) updated information on liquid and dry agents; and (iii) performance requirements for new extinguishing agents.

2. **CANCELLATION.** Advisory Circular 150/5210-6C, Aircraft Fire and Rescue Facilities and Extinguishing Agents, dated January 28, 1985, is canceled.

3. **RELATED READING MATERIAL.**

a. FAR Part 139, Certification and Operations: Land Airports Serving Certain Air Carriers.

b. AC 150/5000-4, Announcement of Availability, Airport Research and Technical Reports, FAA-AS-71-1, Minimum Needs for Airport Firefighting and Rescue Services.

c. AC 150/5210-7, Aircraft Fire and Rescue Communications.

d. AC 150/5210-10, Airport Fire and Rescue Equipment Building Guide.

e. AC 150/5220-10, Guide Specification for Water/Foam Type Aircraft Fire and Rescue Trucks.

f. AC 150/5220-19, Guide Specification for Small Agent Aircraft Rescue and Fire fighting Vehicles .

g. AC 150/5325-5, Aircraft Data.

h. National Fire Protection Association (NFPA) Standard No. 412, Evaluating Foam Fire Equipment Aircraft Rescue and Fire Fighting Vehicles.

i. Report No. FAA-RD-71-57, Evaluation of Aircraft Ground Fire fighting Agents and Techniques.

4. **HOW TO ORDER**.

a. Copies of FAR Part 139 may be purchased from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402

b. Advisory circulars are available through U.S. Department of Transportation, General Services Section, M-443.2, Washington, DC 20590.

c. Copies of National Fire Protection Association (NFPA) Standard No. 412, Evaluating Foam Fire Equipment Aircraft Rescue and Fire Fighting Vehicles, may be ordered from the National Fire Protection Association, Batterymarch Park, Quincy, Massachusetts 02269.

d. Report No. FAA-RD-71-57, Evaluation of Aircraft Ground Fire Fighting Agents and Techniques, is available from the National Technical Information Service, 5285 Port Royal Road, Springfield, Virginia 22161.

DAVID L. BENNETT
Director, Office of Airport Safety and Standards

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CHAPTER 1. OVERVIEW OF EXTINGUISHING AGENTS

1. INTRODUCTION. A systems approach to airport fire fighting and rescue services assures that complete and workable "turnkey" units are specified and provided on airports. This approach includes specific quantities of extinguishing agents for each index. The index determination for aircraft rescue and firefighting is set forth in Part 139.315 of the Federal Aviation Regulations. Fire extinguishing agents are generally characterized as primary, supplementary, and other type of agents. The primary agents are foams, the supplementary agents are dry chemical , and other special agents.

2. PRIMARY AGENTS. Foam used for extinguishing aircraft fires should consist of an aggregation of bubbles of a lower specific gravity than that of hydrocarbon fuels or water. The foam should have strong cohesive qualities and be capable of covering and clinging to vertical and horizontal surfaces. Aqueous foam cools hot surfaces by its high water retention ability and must flow freely over a burning liquid surface to form a tough, air excluding blanket that seals off volatile flammable vapors from access to air or oxygen. Good quality foam should be dense and long lasting, capable of resisting disruption by wind or draft and stable to intense thermal radiation and capable of re-sealing in event of mechanical rupture of an established blanket.

a. Protein Foam. These liquid concentrates consist primarily of hydrolysis products of various proteinaceous materials. They also contain stabilizing additives and inhibitors to protect against freezing, to prevent corrosion of equipment and containers, to resist bacterial decomposition, to control viscosity and to assure readiness for use in emergencies. Foam liquids of different types or different manufacturers should not be mixed unless it is determined that they are compatible and/or completely interchangeable. Although compatibility can be attained by using a dry chemical listed and intended for dual use, most protein foam is not compatible with most dry chemical powders.

b. Aqueous Film Forming Foam (AFFF). These liquid concentrates consist of perfluorinated surfactants(s) with a foam stabilizer, suitable freezing point depressants and viscosity control agents. The AFFF acts both as a barrier to exclude air or oxygen and in addition, produces an aqueous film on the fuel surface capable of suppressing the evolution of fuel vapors. Ideally, the foam blanket produced by the AFFF should be of sufficient thickness so as to be visible before fire fighters rely on its effectiveness as a vapor suppressant.

c. Fluoroprotein Foam. Fluoroprotein Foam falls broadly into two sub-types, one of which has concentrations of a synthetic fluorinated surfactant for the purpose of providing resistance to breakdown by dry chemical powders. The other type has concentrations of a surfactant sufficient to produce an aqueous film on the surface of hydrocarbon fuels. Both types can be used to produce suitable foam, but the manufacturer of the foam-making equipment should be consulted as to the correct concentrate to be used in any particular system (the proportioners installed must be properly designed and/or set for the concentrate being used).

d. Film Forming Fluoroprotein (FFFP) Foam. These agents are also based on protein foam formulations. They are produced by increasing the quantity and quality of the fluorocarbon surfactants added to the protein hydrolyzate. By doing this, the surface tension of the resulting solution which drains from the expanded foam is reduced to the point where it may spread across the surface of a liquid hydrocarbon fuel.

e. Compatibility of AFFF. The Compatibility of AFFF makes it suitable for use with all currently available dry chemical powders and thus adaptable for combined use. Protein and Fluoroprotein foam concentrates are not compatible with AFFF concentrates and should not be mixed, although foams separately generated can be applied to a fire in sequence or simultaneously.

f. Compatibility of Fluoroprotein Foam. Foam liquid concentrates of different types or different manufacture should not be mixed unless it is established that they are completely interchangeable. The compatibility of these foams with any dry chemical agent intended for use on a fire in sequence or simultaneously should be established by test, although such foams are normally compatible with currently available dry chemical powders.

g. Conversion of Equipment. AFFF concentrates are normally used in conventional foam-making devices suitable for producing protein foams. However, the equipment should not be converted for AFFF use without consultation with the manufacturer of the equipment. In addition, the flushing procedures outlined below are suggested at the time of such a conversion:

(1) Remove all protein foam by discharging it through all turrets and nozzles of the fire fighting system;

(2) Flush the system with fresh water by discharging it through the fire system until the water is clear; and

(3) Refill the tanks with AFFF and water and place the truck in service. After about 10 days, drain the AFFF from the tank and flush the fire

3. SUPPLEMENTARY AGENTS. Also referred to as secondary agents. Agents fit into this category are carried on rescue vehicles to handle unique fire fighting requirements most common to airport fire fighting use. Supplementary agents are employed either singly or in combination with foam to accomplish particular aircraft fire fighting operations such as a three dimensional running fuel fires. This class of compounds includes dry chemical powders, halocarbons, agents for magnesium fires, and carbon dioxide.

a. Dry Chemical Powders The earliest use of dry powders in aircraft fire fighting included the use of sodium bicarbonate based products. FAA has published reports, FAA-RD-71-57 and FAA-RD-78-105, which illustrated the advantages of the higher performances of potassium based dry chemical powders over sodium based products. Today the airport fire fighting industry relies almost exclusively on the use of potassium based chemicals in the United States as auxiliary extinguishing agents due to their compatibility with AFFF agents and their reliable fire performance.

(1) Potassium Bicarbonate

(i) Specifications and Testing. The corresponding military specification for this agent was Federal Specification O-D-1407, Dry Chemical, Fire Extinguishing, Potassium Bicarbonate, dated May 3, 1976". The latest available specification for Potassium Bicarbonate is contained in MIL-E-24091C(SH) AMENDMENT 1, Extinguisher, Fire Portable, Potassium Bicarbonate, Dry Chemical, Cartridge-Operated Type, dated 21 September 1990. Product which meet these military specifications or have been tested and certified by an independent testing lab to comply with the individual chemical and physical requirements of these specifications will be consider acceptable.

(ii) Applicability. This paragraph addresses requirements for dry chemical agents used in hand held, portable extinguishers. These specifications do not cover truck-mounted systems, but the requirements here in are appropriate for agents that will be used in extinguishers that are carried in a rescue vehicle. This specification covers one type of dry chemical powder composed largely of pure potassium bicarbonate suitable for fire extinguishers used in conjunction with mechanical foam.

(iii) Equivalency Information. Experimental data developed from large outdoor free burning pool fires have indicated that no great differences exist between dry chemical powders as a group. As a result, a general equivalency of dry chemical powders and protein foam of 1:1 on a weight basis is accepted. Although higher efficiency ratios of individual agents exist, much of this advantage is lost when used under actual rescue conditions. High wind is particularly significant in reducing the efficiency of powders. Therefore, for substitution purposes, 8 pounds of dry chemical powder are considered as equivalent to one U.S. gallon of water for protein foam. Early historical use of dry chemical powders was based on the use of sodium based bicarbonate powders. With the introduction of higher performance potassium based chemicals an exception to this equivalency was made as noted in AC 150/5210-12 which permits the substitution of potassium based chemical for sodium bicarbonate based on a 9:10 or a 10% reduction by weight ratio. In this case, equivalency of powder to water is 7 pounds to one gallon.

The introduction of urea based potassium chemicals have shown significant improvements in fire fighting performance over pure potassium based dry chemicals in certain laboratory small scale fire performance tests. Unfortunately they have not demonstrated any significant improvements in fire fighting performance in large full scale outdoor fire applications over standard specification potassium chemical due to their small physical characteristics glandular size causing them to be influenced greatly by wind conditions. For fire fighting vehicle applications no further reduction by weight will be granted for the use of these products other than the standard 10% reduction granted for all potassium based chemicals.

(iv) Testing. To determine the equivalency of new dry chemicals, the following full scale fire tests are acceptable provided they are performed and certified by an independent testing laboratory. Report FAA-RD-78-105 contains test protocols acceptable for conducting a three dimensional fire pan configuration test, for the testing of dry chemicals powders. These tests shall be accomplished to demonstrate the performance of any new dry chemical product. In addition a 35-foot diameter, 956-square foot, hydrocarbon pool fire shall be extinguished fully three times. The average of these test results shall be compared to a baseline test of PKP Purple K dry chemical powder. Application rates for these tests are between 5 and 7 pounds (7.3 kg/sec to 10 kg/sec). An additional full scale test shall demonstrate the compatibility with AFFF by performing a dual agent application extinguishment of the test product with AFFF and measuring the burn-back resistance of the test fire. For further reference on specific test protocols for dry chemical powders, refer to FAA-RD-71-57 (AGFSRS-71-1 dated February 1972).

b. Halons and Alternates.

(1) Halons. The fire fighting effectiveness of the halocarbons is dependent to a large extent on the boiling point of the liquid agent. Current usage of the halocarbons includes bromochloromethane (CB) (Halon 1011), bromochlorodifluoromethane (Halon 1211), dibromotetrafluoroethane (Halon 2402) and bromotrifluoromethane (Halon 1301). Halocarbons 1011, 1211, and 2402 are effective in outdoor environmental conditions because they can be dispensed as a liquid vapor. Gaseous agents such as Halon 1301 are most effective in confined areas or where drafts and wind conditions are minimal. Large scale fire extinguishing experiments using aircraft fuels indicate that Halons 1011, 1211, and 2402 can be given the same equivalency factor as that for dry chemical powder and protein foam -- namely a 1:1 ratio on a weight basis.

(2) Environmental concerns and response. Halon 1211 has been identified as a stratospheric ozone depleter, and its production was banned in January 1994. Certain uses of existing inventory are allowed.

(3) Halotron I. Subsequent to the U.S. decision to halt production of halon and the use of halon based agents in live fire training because of the environmental effects of Halon, the FAA, teamed with other agencies and industry, and identified an acceptable alternate to using Halon based agents in airport rescue fire fighting vehicles. Several potential agents were evaluated. Only the Halotron I product has completed the full scale fire test performance evaluation and was approved as a alternative fire fighting agent to Halon 1211 for airport fire fighting use. Due to the slight differences in specific gravity of these two chemicals in a 1:1 by volume basis, approximately 468 pounds of Halotron I can be placed in the existing vessel (tank) that holds approximately 500 pounds of Halon 1211. This is the quantity which can normally be found on a airport rescue vehicle. Fire performance tests have shown that Halotron I will generally suppress or extinguish fires in the same manner as Halon 1211. In considering substitution of Halotron I for Halon 1211, the ratio for equivalency in performance might be as great as 1.5 to 1 pound by weight.

(4) Testing for Alternates to Halon 1211. Products seeking approval as substitutes for Halon 1211 must be tested by an independent testing laboratory to determine their equivalency. Test protocols are contained in FAA Report Number DOT/FAA/AR 95/87 Full-Scale Evaluations of Halon 1211 replacement Agents for Airport fire Fighting and include the following test protocols: throw range, inclined plane running fuel fires, engine nacelle running fuel fires, 800 square foot dry pool fires, and simulated wheel landing gear hydraulic fires. The average of three tests for each of the test protocols shall be compared to a baseline extinguishment of Halon 1211 to determine the equivalency of the product.

c. Carbon Dioxide Tests show that low pressure carbon dioxide (CO_2) is more effective in aircraft rescue and fire fighting operations than high pressure CO_2. The tests further indicate that CO_2 can be given parity with dry chemical powder on the basis of 4.4 pounds of CO_2 gas per 2.2 pounds of dry chemical.

4. OTHER AGENTS. **N**ot unique to airport fire fighting but in general there are a hoast of other special use fire extinguishing agents available to the airport fire fighting services. These products generally fit into one of the following categories emulsifiers, wetting agents, and flame inhibiting agents. There is no present requirement to carry such agents on an airport rescue and fire fighting vehicle. but recognizing that these products do exist, in itself requires some accountability for their possible use.

a. Requirements. There is no current requirement for them to meet any known fire performance requirement at this time due to lacking a requirement for their use on any airport. The uniqueness of the possibility that these products may be used as a supplemental agents on airports require that they meet certain minimum corrosion resistance requirements like those required for AFFF agents. Therefore the following corrosion and toxicity requirements are recommended for any agent which is used on a airport rescue vehicle. It will be the responsibility of the airport authority and the specific fire rescue service to assure that products in this category do meet the following minimum requirements. These requirements can be certified by an independent testing laboratory

	Type 3	Type 6
Corrosion rate:		
General		
Cold rolled, low carbon steel (UNS G10100),	1.5	1.5
milli in/yr, maximum		
Copper-nickel (90-10) (UNS C706000),	1.0	1.0
milli in/yr, maximum		
Nickel-copper (70-30) (UNS N04400),	1.0	1.0
milli in/yr, maximum	100	100
Bronze (UNS C90500), milligrams, maximum		
Localized, corrosion-resistant (CRES) steel,	No pits	No pits
(UNS S30400)	500	250
Total halides, p/m, maximum		
Dry chemical compatibiity, burn-back,	360	360
resistance time, seconds, minimum		
Environmental Impact:	500	1000
Toxicity, LC_{50}, mg/L, minimum	1000K	500K
COD, mg/L, maximum	0.65	0.65
$\underline{BOD}_{20}$, minimum		
COD		

b. Compatibility. These agents should not be mixed or proportioned with the normal rescue fire fighting vehicle foam proportioning equipment. These types of products are best used as premixed in separate containers or used with an auxiliary inductor system to the vehicle water supply system. Products of these types have not been extensively testes for compatibility with AFFF primary agents.

c. Enviromental issues. Certain special use agents have shown some abilities to mitigate aircraft related fuel spills and are approved for such use by the Environmental Protection Administration. This is not the intent of this document to provide guidance on how these agent might be used. Bioremediation and cleanup of fuel spills are a complex subject within its self and is best performed by those organizations having jurisdiction.

5. EQUIVALENCY RATINGS OF AGENTS AND SUBSTITUTION. This section contains factors on equivalency which were developed for practical application to determine the individual quantities of agents needed when both protein foam and AFFF are used on an airport, and determine an equivalent level of safety on airports when one agent is substituted for another.

a. The Use of both Protein foam and AFFF. When both of these agents are to be used at the same airport, the total quantity of water to be provided should first be based on the quantity needed if only protein foam was used, then reduce this quantity on a ration of 3 to 2 gallons of water to be provided for AFFF.

b. Units for Equivalency Ratings and Substitution.

(1) Water weighs 8.33 pounds per gallon.

(2) Chlorobromomethane weighs 16.1 pounds per gallon.

(3) Carbon dioxide (CO_2) and dry chemical powders are listed in pounds.

c. Examples of Equivalency.

(1) Eight pounds of dry chemical powder are equivalent to 1 gallon of water for protein foam.

(2) One gallon of CB is equal to 2 gallons of water, or 16 pounds of dry chemical powder, or 12.38 pounds of Halotron I.

(3) 16 pounds of CO_2 equals 8 pounds of dry chemical powder, or 1 gallon of water for protein foam.

(4) The most common CB units are provided on U.S. Air Force trucks in 20 or 40 gallons sizes. Using the figures above, a 40 gallon CB unit would be equivalent to 60 pounds of dry chemical powder.

(5) The most common CO_2 trucks in current use are those owned by the Air Force which carry 4,000 pounds of this agent. Using the figures above, this quantity of agent would be equivalent to 2,000 pounds of dry chemical powder.

6. FACTORS FOR ESTIMATING EQUIVALENCY BETWEEN AGENTS. Table 1 presents conversion factors for estimating equivalency.

Table 1. Factors for Estimating Equivalency.

To convert from	**Multiply by**	**To determine the equivalent in**
pounds of dry chemical powder	0.125	gallons of water for protein foam
gallons of water for protein foam	8.0	pounds of dry chemical powder
pounds of CO_2	0.0625	gallons of water for protein or fluoroprotein foam
gallons of water for protein foam	16.0	pounds of CO_2
pounds of dry chemical powder	2.0	pounds of CO_2
pounds of CO_2	0.5	dry chemical powder
gallons of Halon 1211	16.0	pounds of dry chemical powder
gallons of Halotron I	24.0	pounds of dry chemical powder
pounds of dry chemical powder	0.0625	gallons of CB
gallons of water for protein foam	0.67	gallons of water for AFFF
gallons of water for AFFF	1.50	gallons of water for protein foam

CHAPTER 2. DERIVATION OF RECOMMENDED QUANTITIES

1. OVERVIEW. This chapter contains information on the derivation of recommended quantities of extinguishing agents.

2. THEORETICAL CRITICAL FIRE AREA. The ***"theoretical critical fire area"*** is defined as the area adjacent to the fuselage extending outward in all directions to those points beyond which a large fuel fire would not melt an aluminum fuselage regardless of the duration of the fire exposure time. The theoretical critical fire area serves as a means for categorizing aircraft in terms of the magnitude of the potential fire hazard in which they may become involved.

On the basis of FAA research, an ICAO Rescue and Fire Fighting Panel also developed what is considered a working definition of the theoretical critical fire area. In this area, the fire must be controlled to ensure temporary fuselage integrity and provide an escape area for aircraft occupants.

The theoretical critical area serves as a means for categorizing aircraft in terms of the magnitude of the potential fire hazard in which they may become involved. It is not intended to represent the average, maximum, or minimum spill fire size associated with a particular aircraft. The formulas for calculating the theoretical critical fire area (TC) for different sizes of aircraft are shown below, and the results of these calculations for the various indexes are presented in chapters 3 and 4.

TC = (L) (100 feet + W), when L is more than 65 feet, and
TC = (L) (40 feet + W), when L is less than 65 feet

where:

TC = the theoretical critical fire area in square feet;
L = the average length of the aircraft; and
W = the average width of the aircraft fuselage.

3. PRACTICAL FIRE AREA. In survivable aircraft crash the ***"practical fire area"*** is smaller than the theoretical area. RFFP II developed material indicating the practical area is two-thirds of the theoretical area.

The practical fire area and the related quantities of extinguishing agents are based on criteria formulated during the Second Meeting of the ICAO Rescue and Fire Fighting Panel (RFFP II) in June 1972. The Panel's work included a study of extinguishing agents used on actual aircraft fires. In 99 out of 106 such fires, the quantities of agents used were less than those previously recommended by ICAO, substantiating the requirement for the reduced quantities recommended in this circular.

4. BACKGROUND ON QUANTITIES OF EXTINGUISHING AGENTS.

a. Control and Extinguishment Times. The recommended quantities of extinguishing agents, application rates, etc., in this circular are based on consideration of the following:

(1) Control Time. Time required from arrival of the first fire fighting vehicle and the beginning of water/agent discharge to reduce the initial intensity of the fire by 90 percent. The equipment and techniques to be used should be capable of substantially controlling the fire in the practical fire area in one minute. Substantial control time not exceeding one minute has been achieved in the majority of the aircraft accidents as noted in reports collected by the Rescue and Fire Fighting Panels.

(2) Extinguishment Time. Time required from arrival of the first fire fighting vehicle to extinguish the fire completely.

(3) Substantial Control or Extinguishment. While complete extinguishment of the fire is a highly desirable objective, from a practical standpoint it is necessary that substantial control of the fire be achieved in order for occupants to escape or be rescued.

b. Application Rates.

(1) Protein Foam. For protein foam, an application rate of 0.20 U.S. gal/min/ft^2 has been established as the rate for single water/agent attack at which substantial control can be achieved within one minute under a wide variety of simulated accident conditions. Experiments of dual agent attack with simultaneous discharge of both a primary agent (foam) and a supplementary agent (dry chemical powder, or halocarbon (vaporizing liquid agents)) have shown that the total agent requirement by weight to obtain a one-minute substantial control time is essentially the same as that for a single agent attack. Therefore, the combined agent application rate by weight for dual agent attack should be the same as that for single agent attack with foam.

(2) Aqueous Film Forming Foam (AFFF). The application rate for AFFF to obtain substantial fire control within one minute has been determined to be 0.13 U.S. gal/min/ft^2 under a wide variety of simulated accident conditions.

c. Discharge Rates. The discharge rates (gallons per minute) in Table 3 were calculated to obtain a one minute substantial control time on the practical fire area. The discharge rate for each airport index was determined by multiplying the practical area by the application rate.

d. Calculating Quantities of Foam Extinguishing Agents. Experience and test data indicate that the quantities of agents needed to control and extinguish the fire should be determined separately. The first quantity (Q_1) is the amount of foam required to obtain a one-minute substantial control time in the practical fire area. The second quantity (Q_2) is that required for continued control of the fire after the first minute of application and/or for complete extinguishment of the fire. Thus, the quantities of water/agent (Q) as shown in Tables 3 and 5 was found by the formula:

$Q = Q_1 + Q_2$.

(1) Quantity (Q_1). This quantity of solution was calculated by multiplying the practical fire area by the foam solution application rate by one minute.

(2) Quantity (Q_2). This amount of additional foam solution is needed to maintain the established foam blanket and/or to extinguish the fire in the practical fire area. Q_2 depends upon several factors such as state of the fire after the initial attack, the appropriate application rate for the fire area and the duration of the containment phase. Since numerous variables are involved, this quantity has been determined from test data and analyses of actual aircraft rescue and fire fighting operations to be a percentage factor of Q_1 as listed below:

(i) For Airport Indexes A through E, the percentage factors for determining Q_2 are: 66 percent for Index A; 100 percent for Index B; 129 percent for Index C; 152 percent for Index D; and 170 percent for Index E.

(ii) For the General Aviation Airports, the percentage factors for determining Q_2 are: 22 percent for Index 1 and 37 percent for Index 2. Indexes for General Aviation airports are discussed in Chapter 4.

(3) Sample Calculation of Q. As an example, in determining the Quantity (Q) needed for an Index B airport, the application rate for protein foam is 0.20 gal/min/ft^2 (paragraph 4b(1)), and the practical fire area is 7,959 square feet. Therefore, the quantity of water for protein foam solution is:

Q_1	=	practical fire area x application rate x one minute
	=	7,959 sq. ft. x 0.20 gal/min/ft^2 x 1 min.
	=	1,591.80 gallons
Q_2	=	Index B factor x Q_1
	=	100% x 1,591.80 gal.
	=	1,591.80 gallons
Q	=	Q_1 + Q_2
	=	1,592 gal. + 1,592 gal.
	=	3,184 gallons

CHAPTER 3. AIRPORTS SERVING CAB-CERTIFICATED AIR CARRIERS/COMMERCIAL SERVICE

1. OVERVIEW. This chapter contains information about quantities of agents recommended for Index A through E airports.

2. THEORETICAL CRITICAL FIRE AREA AND PRACTICAL FIRE AREA . Table 2 summarizes the aircraft dimensions, theoretical critical fire area, and practical fire area for each of the five indexes.

Table 2. Theoretical Critical and Practical Fire Areas by Index

Index (*)	Overall Length (ft.)		Average Length (ft.)	Average Fuselage Width (ft.)	Theoretical Critical Fire Area (sq.ft.)	Practical Fire Area (sq.ft)
	Lower Limit	Upper Limit				
A		90	75	10	8,250	5,527
B	90	126	108	10	11,880	7,959
C	126	160	143	10	15,730	10,539
D	160	200	180	20	21,600	14,472
E	200		225	20	27,000	18,090

3. QUANTITIES OF FIRE EXTINGUISHING AGENTS. Table 3 summarizes the quantities of primary and supplementary agents by index. The quantities presented in Table 3 are rounded to the nearest 10 gallons. For practical application, it is suggested that the quantities in Columns 2 and 4 be adjusted upward to coincide with the conventional capacities of water tanks, which are normally sized in increments of 500 gallons.

Table 3. Quantities of Fire Extinguishing Agents for Index A - E.

Index (*)	Primary Agents				Supplementary Agents
	Protein Foam		Aqueous Film Forming Foam (AFFF)		
	Water for Foam Production (gal.) Q	Solution Application Rate (g.p.m.) Q_1	Water for AFFF Production (gal.) Q	Solution Application Rate (g.p.m.) Q_1	Dry Chemical Powders (lbs.)
A	1,830	1,100	1,190	720	500
B	3,180	1,590	2,070	1,050	750
C	4,820	2,110	3,140	1,370	1,000
D	7,290	2,890	4,740	1,880	1,500
E	9,770	3,620	6,350	2,350	1,500

(*) Indexes A through E in this Table refer to those identified in Part 139.315

CHAPTER 4. QUANTITIES FOR GENERAL AVIATION AIRPORT PROTECTION

1. OVERVIEW. This chapter contains information about the quantities of agents recommended for general aviation airports. These airports are divided into two indexes, described as follows:

a. General aviation airport indexes. For purposes of this advisory circular, they are based on the number of annual departures. While the ICAO RFFP II used a slightly different method than the U.S. for determining these indexes, the results are similar. The departure factor used to establish indexes indicates the representative type of aircraft using the airport, upon which the recommended level of protection is based.

b. Index 1 Apply to airports having at least 1,825 annual departures of aircraft more than 30 feet but no more then 45 feet long.

c. Index 2 Apply to airports having at least 1,825 annual departures of aircraft more than 45 feet but no more than 60 feet long.

d. Other. On general aviation airports having operations involving aircraft more than 60 feet long, the levels of protection should be determined by using the guidance in Chapter 3.

2. THEORETICAL CRITICAL FIRE AREA AND PRACTICAL FIRE AREA. Table 4 summarizes the aircraft dimensions, theoretical critical fire area, and practical fire area for general aviation airports.

Table 4. Theoretical Critical and Practical Fire Areas for General Aviation Airports.

Index	Data on Aircraft Length (ft.)			Average Width of Fuselage (ft.)	Theoretical Critical Fire Area (sq.ft.)	Practical Fire Area (sq.ft.)
	Lower Limit	Upper Limit	Average Length			
1	30	45	38	6	1,748	1,171
2	45	60	53	10	2,650	1,775

3. QUANTITIES OF FIRE EXTINGUISHING AGENTS. Table 5 summarizes the quantities of primary and supplementary agents for general aviation indexes. The quantities presented in Table 5 are rounded to the nearest 10 gallons. For practical application, the quantities in the second and fourth columns should be adjusted to coincide with conventional water tanks of 200, 300, and 500 gallon capacities.

Table 5. Scales of Protection for General Aviation.

Index	Primary Agents: AFFF or Protein Foam				Supplementary Agent
	AFFF		Protein Foam		Dry Chemical Powders (lbs.)
	Water for foam production (gal.)	Water/ Agent application rate (g.p.m.)	Water for foam production (gal.)	Water/ Agent application rate (g.p.m.)	
	Q	Q_1	Q	Q_1	
1	190	150	290	230	300
2	310	230	490	350	400

CHAPTER 5. PERFORMANCE REQUIREMENTS FOR PRIMARY AGENTS

1. OVERVIEW. This chapter specifies the performance requirements for all primary liquid concentrate agents, consisting of fluorocarbon surfactants and other compounds. The concentrates shall be classified as Type 3 which is used as three parts concentrate to 97 parts water by volume; or Type 6 which is used as six parts concentrate to 94 parts water by volume solution. The intent is to have one fire performance requirement for all primary agents used on FAA certificated airports.

2. QUALIFICATIONS. Liquid concentrates fire extinguishing agents furnished for use at FAA Certificated airports shall meet the following requirements. These requirements may be met by using of the following methods:

a. Liquid concentrates shall meet the military specifications provided in MIL-F-24385F, dated 7 January 1992 or later version.

b. Liquid concentrates which have been demonstrated and certified by an independent testing laboratory to meet the performance and physical characteristics of the same test protocols. It shall be the manufacturers responsibility to maintain suitable records and sample of agents for analysis for a period of five (5 years if they elect to use independent laboratory certification. These documentation must be available for review if the airport authority purchaser or FAA request them.

3. MATERIALS. Concentrates shall consist of fluorocarbon surfactants plus other compounds as required to conform to the requirements specified below. The material shall have no adverse effect on the health of personnel when used for its intended purpose.

4. CONCENTRATE CHARACTERISTICS. Concentrates shall conform to the chemical and physical requirements shown in Table 6.

a. Film Formation and Sealability. The foam produced film shall spread over the fuel surface and seal off vapor production to prevent sustained ignition.

b. Stability. The concentrate (Type 3 or Type 6) and a 3 percent premix solution of Type 3 or a 6 percent premix solution of Type 6 as applicable shall conform to the following requirements after 10 days storage at 65°Celsius (°C) ±2.0°C:

(1) Spreading Coefficient: See Table 6.

(2) Foamability: See Table 6.

(3) Film Formation and Sealability: See Paragraph 3.a above.

(4) Fire Performance: 28 sq. ft. fire, 1.5 and 3 percent of Type 3, and 3 and 6 percent of Type 6 fresh and sea water solutions. Also see Paragraph 4 below.

(5) Stratification: No visible evidence following the test.

(6) Precipitation: 0.05 percent by volume.

c. Compatibility. The concentrates of one manufacturer shall be compatible in all proportions with concentrate furnished by other manufacturers listed on the qualified products list of military specifications agents. The materials shall also be compatible with materials in inventory which were acquired under previous issues of this specification and known to be still in use in significant quantities. The concentrate shall conform to the following requirements after 10 days storage at 65° C ±2.0° C:

(1) Foamability: See Table 6.

(2) Film Formation and Sealability: See Paragraph 3.b.(3), above.

(3) Fire Performance 28 sq.ft, 3 percent of Type 3 and 6 percent of Type 6 fresh and sea water solution. Also see paragraph 4, below.

(4) Stratification: No visible evidence following test.

(5) Precipitation: 0.05 percent by volume.

d. Total Fluorine Content. The total fluorine content of the AFFF shall be determined and shall not deviate more than 15 percent of the value determined and reported at time of qualification report.

Table 6. Chemical and Physical Requirements for Concentrates or Solution.

Requirements	Type 3	Type 6
Refractive index, minimum	1.3630	1.3580
Viscosity, centistockes		
Maximum at 5°C	20	10
Minimum at 25°C	2	2
Hydrogen ion concentration (pH)	7.0 to 8.5	7.0 to 8.5
Spreading coefficient, minimum	3	3
Foamability:		
Foam expansion, minimum	5.0	5.0
Foam 25% drainage time, minutes, minimum	2.5	2.5
Corrosion rate:		
General		
Cold rolled, low carbon steel (UNS G10100), milli in/yr, maximum	1.5	1.5
Copper-nickel (90-10) (UNS C706000), milli in/yr, maximum	1.0	1.0
Nickel-copper (70-30) (UNS N04400), milli in/yr, maximum	1.0	1.0
Bronze (UNS C90500), milligrams, maximum	100	100
Localized, corrosion-resistant (CRES) steel, (UNS S30400)	No pits	No pits
Total halides, p/m, maximum	500	250
Dry chemical compatibility, burn-back, resistance time, seconds, minimum	360	360
Environmental Impact:		
Toxicity, LC_{50}, mg/L, minimum	500	1000
COD, mg/L, maximum	1000K	500K
$\frac{BOD_{20}}{COD}$, minimum	0.65	0.65

5. FIRE PERFORMANCE. The foam shall conform to the fire performance requirements shown in Table 7.

Table 7. Fire Performance

	AFFF solutions, percent		
	1.5% of Type 3 3% of Type 6	3% of Type 3 6% of Type 6	15% of Type 3 30% of Type 6
	(Fresh and Sea)	(Fresh and Sea)	(Sea)
28 sq.ft. fire:			
Foam application time to extinguish, seconds, maximum	45 seconds	30 seconds	55
Burnback time of resulting foam cover, seconds, minimum	300 seconds	360 seconds	200
50 sq. ft. fire:			
Foam application time to extinguish, seconds, maximum		50 (Sea only)	
Burnback time of resulting foam cover, seconds, minimum		360	
40 seconds summation, minimum		320	

The fire performance tests that is defined above in Table 7 is for the testing of AFFF primary extinguishing agents. The only change permitted to maintain a unified testing protocol for agents other than AFFF primary agents is a greater application rate for of these other foams. Historically the application rates were reduced as better fire fighting foams were developed, for example 0.13 gpm/ft^2 (5.5 Lpm/m^2) for AFFF agents. Should any of the other foams not be able to extinguish the performance fire test and/ or pass the burnback r resistance requirements as stated above they would be considered unacceptable quality for airport use.

a. AFFF = 0.13 gpm/ft^2 (5.5 Lpm/m^2)

b. PROTEIN FOAM = 0.20 gpm/ft^2 (8.2 Lpm/m^2)

c. FILM FORM FLUOROPROTEIN FOAM = 0.18 gpm/ft^2 (7.5Lpm/m^2)

CHAPTER 6. TESTING AND QUALITY ASSURANCE FOR EXTINGUISHING AGENTS

1. QUALITY CONTROL AND PERFORMANCE. While it is recognized that acceptance testing of extinguishing agents is necessary, the technical characteristics, quality, stability compatibility, etc., cannot be determined during other system tests or demonstrations (e.g., for trucks). Therefore, airport management should request that prospective bidders or suppliers of fire extinguishing agents furnish indication of tests on performance and quality by a recognized testing laboratory. Technical data concerning evaluation of agents and information on the characteristics of foam extinguishing agents and equipment are contained in NFPA No. 412.

2. RESPONSIBILITY FOR INSPECTION. Unless otherwise specified by the airport authority, the manufacturer is responsible for the performance of all inspection requirements. Except as otherwise specified in the contract, the contractor may use his own or any other facilities suitable for the performance of the inspection requirements, unless disapproved by the Government. The Government reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to ensure supplies and services conform to prescribed requirements..

3. QUALITY OF INSPECTIONS. Qualification inspection shall be conducted at a laboratory satisfactory to the FAA Administrator.

APPENDIX 1. EXTINGUISHING AGENTS FOR VARIOUS AIRCRAFT FIRES

Situation	**Agents**
Spill of Fuel without Fire	AFFF or Protein or Fluoroprotein Foam Blanket Water Spray Flushing
Spill Fire	AFFF Dry Chemical Powder Protein or Fluoroprotein Foam
Nacelle	Dry Chemical Powder Halocarbons CO_2
Wheel Fire	Dry Chemical Powder Halocarbons
Magnesium Fire	TEC Magnesium Extinguishing Agent Met-L-X extinguishers
Fires in Unoccupied Enclosed Spaces	CO_2 Halocarbons[1] Water Spray
Fires in Occupied Enclosed Spaces	Water Spray
3-D Exterior Fires with Spilling Fuel	AFFF, Protein Foam or Fluoroprotein Foam in combination with Dry Chemical Powder or Halocarbons

[1] Primarily intended for application outdoors, they are, however, recognized as being effective on fires in unoccupied enclosed spaces such as nacelles. However, because of their toxicity, these agents require training in use and application.